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The Contents.

An Eſſay of Dr. John Wallis, *exhibiting his* Hypotheſis *about the* Flux and Reflux of the Sea, *taken from the Conſideration of the* Common Center of Gravity of the Earth and Moon; *together with an* Appendix *of the ſame, containing an* Anſwer *to ſome* Objections, *made by ſeverall Perſons againſt that* Hypotheſis. *Some Animadverſions of the ſame* Author *upon Maſter* Hobs's *late Book,* De Principiis & Ratiocinatione Geometrarum.

An Eſſay *Of Dr.* John Wallis, *exhibiting his* Hypotheſis *about the* Flux and Reflux of the Sea.

HOw abſtruſe a ſubject in Philoſophy, the *Flux and Reflux of the Sea* hath proved hitherto, and how much the ſame hath in all Ages perplexed the Minds even of the beſt of *Naturaliſts*, when they have attempted to render an Account of the Cauſe thereof, is needleſs here to repreſent. It may perhaps be to more purpoſe, to take notice, that all the deficiencies, found in the *Theories* or *Hypotheſes*, formerly invented for that End, have not been able to deterre the Ingenious of *this* Age from making farther ſearch into that Matter: Among whom that Eminent Mathematician Dr. *John Wallis*, following his happy *Genius* for advancing reall Philoſophy, hath made it a part of his later Inquiries and Studies, to contrive and deduce a certain Hypotheſis concerning that *Phænomenon*, taken

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from the Conſideration of the *Common Center of Gravity of the Earth and Moon*, This being by ſeveral Learned Men lookt upon, as a very rational Notion, it was thought fit to offer it by the Preſs to the Publick, that other Intelligent Perſons alſo might the more conveniently and at their leiſure examine the *Conjecture* (the Author, ſuch is his Modeſty, preſenting it no otherwiſe) and thereupon give in their ſenſe, and what Difficulties may occur to them about it, that ſo it may be either confirm'd or laid aſide accordingly; As the *Propoſer* himſelf expreſly deſires in the Diſcourſe, we now, without any more *Preamble*, are going to ſubjoyn, as it was by him addreſſed, by way of Letter, from *Oxford* to Mr. *Boyle April* 25. 1666. and afterwards communicated to the *R. Society*, as follows:

YOu were earneſt with me, when you laſt went from hence, that I would put in writing ſomewhat of that, which at divers times, theſe three or four years laſt paſt, I have been diſcourſing with your ſelf and others concerning the *Common Center of Gravity of the Earth and Moon*, in order to ſalving the *Phænomena* as well of the *Seas Ebbing and Flowing*; as of ſome perplexities in *Aſtronomical Obſervations* of the *Places* of the Celeſtial Bodies.

How much the World, and the great Bodies therein, are manag'd according to the *Laws of Motion*, and *Statick Principles*, and with how much more of clearneſs and ſatisfaction, many of the more abſtruſe *Phænomena* have been ſalved on ſuch Principles, within this laſt Century of years, than formerly they had been; I need not diſcourſe to you, who are well verſed in it. For, ſince that *Galilæo*, and (after him) *Torricellio*, and others, have applied *Mechanick* Principles to the ſalving of *Philoſophical* Difficulties; *Natural Philoſophy* is well known to have been rendered more intelligible, and to have made a much greater progreſs in leſs than an hundred years, than before for many ages.

The *Seas Ebbing and Flowing*, hath ſo great a connexion with the *Moons* motion, that in a manner all Philoſophers (whatever other Cauſes they have joyned with it) have attributed much of its cauſe to the *Moon*; which either by ſome *occult quality*, or *particular influence*, which it hath on moyſt Bodies, or by ſome *Magnetick vertue*, drawing the water towards it, (which ſhould therefore make the Water there *higheſt*, where the Moon is *vertical*) or by its gravity and preſſure downwards upon the Terraqueous Globe (which ſhould make it *loweſt*, where the Moon is *vertical*) or by whatever other means (according to the ſeveral Conjectures of inquiſitive perſons,) hath ſo great an influence on, or at leaſt a connexion with, the Sea's Flux and Reflux, that it would ſeem very unreaſonable, to ſeclude the conſideration of the Moons motion from that of the Sea: The *Periods of Tides* (to ſay nothing of the greatneſs of them near the New-moon and Full-moon) ſo conſtantly waiting on the Moon's motion, that it may be well preſumed, that either the one is governed by the other, or at leaſt both from ſome common cauſe.

But the firſt that I know of, who took in the conſideration of the *Earth's* motion, (*Diurnal* and *Annual*) was *Galilæo*; who in his *Syſteme of the World*, hath a particular diſcourſe on this ſubject: Which, from the firſt time that I ever read it, ſeemed to me ſo very rational, that I could never be of other opinion, but that the true Account of this great *Phænomenon* was to be referred to the Earths motion, as the *Principal* cauſe of it: Yet that of the Moon (for the reaſons above mentioned) not to be excluded, as to the determining the *Periods of Tides*, and other circumſtances concerning them. And though it be manifeſt enough, that *Galilæo*, as to ſome particulars, was miſtaken in the account which there he gives of it; yet that may be very well allowed, without any blemiſh to ſo deſerving a perſon, or prejudice to the *main Hypotheſis*: For that Diſcourſe is to be looked upon onely as an *Eſſay* of the *general Hypotheſis*; which as to *particulars* was to be afterwards adjuſted, from a good *General Hiſtery of Tides*; which it's manifeſt enough that he had not; and which is in a great meaſure yet wanting. For were the matter of Fact well agreed on, it is not likely, that ſeveral Hypotheſes ſhould ſo far differ, as that one ſhould make the Water *then* and *there* at the Higheſt, *where* and *when* the other makes it at the Loweſt: as when the Moon is Vertical to the place.

And what I ſay of *Galilæo*, I muſt in like manner deſire to be underſtood of what I am now ready to ſay to you. For I do not profeſs to be ſo well ſkilled in the Hiſtory of Tides, as that I will undertake preſently to accommodate my *general Hypotheſis* to the *particular caſes*; or that I will indeed undertake for the certainty of it, but onely as an *Eſſay* propoſe it to further conſideration; to ſtand or fall, as it ſhall be found to anſwer matter of Fact. And truly had not your importunity (which is to me a great Command) required me to do it; I ſhould not ſo eaſily have drawn up any thing about it, till I had firſt ſatisfied my ſelfe, how well the Hypotheſis would anſwer Obſervation: Having for divers years neglected to do it, waiting a time when I might be at leiſure throughly to proſecute this deſign.

But there be two reaſons, by which you have prevailed with me, at leaſt to do ſomething. *Firſt*, becauſe it is the common Fate of the *Engliſh*, that out of a modeſty, they forbear to publiſh their Diſcoveries, till proſecuted to ſome good degree of certainty and perfection; yet are not ſo wary, but that they diſcourſe of them freely enough to one another, and even to Strangers upon occaſion; whereby others, who are more haſty and venturous, comming to hear of the notion, preſently publiſh ſomething of it, and would be reputed thereupon, to be the firſt Inventers thereof: though even that little, which they can then ſay of it, be perhaps much leſs, and more imperfect, than what the true Authors could have publiſhed long before, and what they had really made known (publikely enough, though not in print) to many others. As is well known amongſt us as to the buſineſs of the *Lymphatick Veſſels* in *Anatomy*: the *Injection of Liquors into the veines of Living animals*; the *Exhibiting of a ſtraight line equal to a crooked*; the *Spot in Jupiter*, whence his motion about his own Axis may be demonſtrated; and many other the like conſiderable Inventions.

The *other* Reaſon (which, with me, is more really of weight, though even the former be not contemptible) is, becauſe, as I have been already for at leaſt three or four years laſt paſt diverted from proſecuting the inquiry or perfecting the Hypotheſis, as I had thoughts to do; ſo I do not know, but like Emergencies may divert me longer; and whether I ſhall ever ſo do it;as to bring it to perfection,I cannot determine. And therefore, if as to my ſelf any thing ſhould *humanitus accidere;* yet poſſibly the notion may prove worth the preſerving to be proſecuted by others, if I do it not. And therefore I ſhall, at leaſt to your ſelf, give ſome general account of my preſent imperfect and undigeſted thoughts.

I conſider therefore, that in the Tides, or the Flux and Reflux of the Sea,beſides extraordinary Extravagancies,or Irregularities, whence great Inundations or ſtrangly high Tides do follow, (which yet perhaps may prove not to be ſo meerly accidental as they have been thought to be, but might from the regular Laws of Motion,if well conſidered, be both well accounted for,and even foretold;) There are theſe *three* notorious Obſervations made of the Reciprocation of Tides. *Firſt*, the *Diurnal* Reciprocation; whereby twice in ſomewhat more than 24. hours, we have a Floud and an Ebbe; or a High-water and Low-water. *Secondly*, the *Menſtrual*; whereby in one *Synodical* period of the Moon,ſuppoſe from Full-moon to Full-moon,the Time of thoſe Diurnal Viciſſitudes doth move round through the whole compaſs of the Νυχθήμερον, or Natural day of twenty four hours: As for inſtance,if at the Full-moon the full Sea be at ſuch or ſuch a place juſt at Noon, it ſhall be the next day (at the ſame place) ſomewhat before One of the clock; the day following, between One and Two; and ſo onward, till at the New-moon it ſhall be at midnight; (the other Tide, which in the Full-moon was at midnight,now at the New-moon coming to be at noon;) And ſo forward till at the next Full-moon, the Full-ſea ſhall (at the ſame place) come to be at Noon again: Again, That of the Spring-tides and Neap-tides (as they are called;) about the Full-moon and New-moon the Tides are at the Higheſt, at the Quadratures the Tides are at the Loweſt: And at the times intermediate, proportionably. *Thirdly*,the *Annual*; whereby it is obſerved,that at ſometimes of the year, the Spring-tides are yet much higher than the Spring-tides at other times of the year: Which Times are uſually taken to be at the Spring and Autumne; or the two Æquinoxes; but I have reaſon to believe (as well from my own Obſervations, for many years, as of others who have been much concerned to heed it, whereof more will be ſaid by and by;) that we ſhould rather aſſign the beginnings of *February* and *November*, than the two *Æquinoxes.*

Now in order to the giving account of theſe three Periods, according to the *Laws of Motion* and *Mechanick Principles*; We ſhall *firſt* take for granted, what is now adayes pretty commonly entertained by thoſe, who treat of ſuch matters; *That a Body in motion is apt to continue its motion, and that in the ſame degree of celerity, unleſs hindred by ſome contrary Impediment*; (like as a Body at reſt, to continue ſo, unleſs by ſome ſufficient mover, put into motion:) And accordingly (which daily experience teſtifies) if on a Board or Table, ſome looſe incumbent weight, be for ſome time moved, & have thereby contracted an *Impetus* to motion at ſuch a rate; if that Board or Table chance by ſome external obſtacle, or otherwiſe, to be ſtopped or conſiderably retarded in its motion, the incumbent looſe Body will ſhoot forward upon it: And contrarywiſe, in caſe that Board or Table chance to be accelerated or put forward with a conſiderably greater ſpeed than before, the looſe incumbent Body, (not having yet obtained an equal *Impetus* with it) will be left behind, or ſeem to fly backward upon it. Or, (which is *Galilæo*'s inſtance,) if a broad Veſſel of Water, for ſome time evenly carried forward with the water in it, chance to meet with a ſtop, or to ſlack its motion, the Water will daſh forward and riſe higher at the fore part of the Veſſel: And, contrarywiſe, if the Veſſel be ſuddenly put forward faſter than before; the Water will daſh backwards, and riſe at the hinder part of the Veſſel. So that an Acceleration or Retardation of the Veſſel, which carries it, will cauſe a riſing of the Water in one part, and a falling in another: (which yet, by its own weight, will again be reduced to a Level as it was before.) And conſequently, ſuppoſing the Sea to be but as a looſe Body, carried about with the Earth, but not ſo united to it, as neceſſarily to receive the ſame degree of *Impetus* with it, as its fixed parts do; The acceleration or retardation in the motion of this or that part of the Earth, will cauſe (more or leſs, according to the proportion of it) ſuch a daſhing of the Water, or riſing at one part, with a Falling at another, as is that, which we call the Flux and Reflux of the Sea.

Now this premiſed, We are *next*, with him, to ſuppoſe the Earth carried about with a double motion; The one *Annual*, as (*Fig.* 1.) in B E C the great Orb, in which the Center of the Earth B, is ſuppoſed to move about the Sun A.

The other *Diurnal*, whereby the whole moves upon its own *Axis*, and each point in its ſurface deſcribes a Circle, as D E F G.

It is then manifeſt, that if we ſuppoſe, that the Earth moved but by any one of theſe motions, and that regularly, (with an equal ſwiftneſs;) the Water, having once attained an equal *Impetus* thereunto, would ſtill hold equal pace with it; there being no occaſion, from the Quickening or Slackening of the Earths motion, (in that part where the Water lyeth) for the Water thereon either to be caſt Forward or fall Backward, and thereby to accumulate on the other parts of the Water: But the true motion of each part of the Earths ſurface being compounded of thoſe two motions, the *Annual* and *Diurnal*; (the *Annual* in B E C being, as *Galilæo* there ſuppoſeth, about three times as faſt as a *diurnal* motion in a great Circle, as D E F;) while a Point in the Earths ſurface moves about its Center *B*. from G. to D. and E. and at the ſame time, its Center B. be carried forwards to C; the true motion of that Point forwards, is made up of both thoſe motions; to wit, of B to C, and of G to E; but while G moves by D to E, E moves backward by F to G, contrary to the motion of B to C; ſo that the true motion of E, is but the difference of B C, and E G: (for, beſide the motion of B, above the Center; G is alſo put forward as much as from G to E; and E put backward as much as from E to G:) ſo that the *Diurnal* motion, in that part of the Earth, which is next the Sun, as E F G, doth abate the progreſs of the *Annual*, (and moſt of all at F;) and in the other part, which is from the Sun, as G D E, it doth increaſe it, (and moſt of all at D.) that is, in the day time there is abated, in the night time is added to the *Annual* motion, about as much as is G E, the Earths *Diameter*. Which would afford us a Cauſe of two Tides in twenty four hours; the One upon the greateſt Acceleration of motion, the Other upon its greateſt Retardation.

And thus far *Galilæo*'s Diſcourſe holds well enough; But then in this it comes ſhort; that as it gives an Account of two Tides; ſo thoſe two Tides are alwayes to be at F and D; that is, at *Noon* and *Midnight*; whereas Experience tells us, that the Time of Tides, moves in a *moneths ſpace* through all the 24. hours. Of which he gives us no account. For though he do take notice of a Menſtrual Period; yet he doth it onely as to the *Quantity* of the Tides; greater or leſs; not as to the *Time* of the *Tides*, ſooner or later.

To help this, there is one (*Vid.* * *Jo. Baptiſta Balianus*) who makes the *Earth* to be but a *ſecondary* Planet; and to move, not directly about the Sun, but about the Moon, the Moon meanwhile moving about the Sun; in like manner as we ſuppoſe the Earth to move about the Sun, and the Moon about it.

* *Vid. Riccioli Almageſt. novum*, Tom. 1. lib. 4. cap. 10. n. 111. pag. 216 2.

But this, though it might furniſh us with the foundation of a *Menſtrual* Period of Accelerations and Retardations in the compound motion of ſeveral parts of the Earths ſurface; yet I am not at all inclined to admit this as a *true Hypotheſis*, for divers Reaſons, which if not demonſtrative, are yet ſo conſonant to the general Syſteme of the World, as that we have no good ground to disbelieve them. For 1. The Earth being undeniably the greater Body of the two (whereof there is no doubt to be made) it cannot be thought probable, that this ſhould be carried about by the Moon, leſſer than it ſelf: The contrary being ſeen, not onely in the *Sun*, which is bigger than any of the Planets, which it carryes about; but in *Jupiter*, bigger than any of his *Satellites*; and *Saturne*, bigger than his. 2. As the *Sun* by it's motion about it's own Axis, is with good reaſon judged to be the *Phyſical* cauſe of the *Primary* Planets moving about it; So there is the like reaſon to believe, that *Jupiter* and *Saturne* moving about their Axes, are the Phyſical cauſe of their *Satellites* moving about them, which motion of *Jubiter* hath been of late diſcover'd, by the help of a *fixed* Spot diſcern'd in him; and we have reaſon to believe the like of *Saturne*. Whether *Venus* and *Mercury* (about whom no *Satellites* have been yet obſerved) be likewiſe ſo moved; we have not yet the like ground to determine: But we have of *Mars*; from the Obſervations of Mr. *Hook* made in *February* and *March* laſt, and by him communicated to the *Royal Society*, and ſince Printed in the *Tranſactions*, publiſhed *Apr.* 2. 1666. conſonant to the like obſervations of *Jupiter*, made by him in *May*. 1664, and ſince communicated to the ſame *Society*; and then publiſhed in the *Tranſactions*, of *March*. 6. then next following. Now that the Earth hath ſuch a motion about its own Axis (whereby it might be fitted to carry about the Moon) is evident by its *Diurnal* motion. And it ſeems as evident that the Moon hath not; becauſe of the ſame ſide of the Moon alwaies turned towards us; which could not be, if the Moon carried the Earth about: Unleſſe we ſhould ſay, that it carries about the Earth in juſt the ſame Period, in which it turnes upon its own Axis: Which is contrary to that of the Sun carrying about the Planets: the ſhorteſt of whoſe Periods, is yet longer than that of the Suns moving about its own Axis. And the like of *Jupiter*, ſhorter than the Period of any of his *Satellites*; if at leaſt the Period of his converſion about his Axis, lately ſaid to be obſerved, prove true. (Of *Saturn* we have not yet any Period aſſigned; but it's likely to be ſhorter, than that of his *Satelles*.) And therefore we have reaſon to believe, not that by the Moons motion about its Axis the Earth ſhould be carried by a contemporary Period (whereby the ſame face of the Moon ſhould be ever towards us;) but that by the Earths revolution abouts its Axis in 24. hours, the Moon ſhould be carried about it in about 29. dayes, without any motion on its own Axis: And accordingly, that the *Secondary* Planets about *Jupiter* and *Saturn*, are not (like their *Principals*) turned about their own Axis. And therefore I am not at all inclined to believe, that the *Menſtrual* Period of the Tides with us, is to be ſalved by ſuch an Hypotheſis.

In-ſtead of this, that *Surmiſe* of mine, (for I dare not yet, with confidence give it any better name,) of what I have ſpoken to you heretofore, (and which hath occaſioned this preſent account which I am now giving you,) is to this purpoſe.

The Earth and Moon being known to be Bodies of ſo great connexion, (whether by any Magnetick, or what other, Tye, I will not determine; nor need I, as to this purpoſe;) as that the motion of the one follows that of the other;(The Moon obſerving the Earth as the Center of its *periodick* motion:) may well enough be looked upon as *one Body*, or rather *one Aggregate of Bodies*, which have *one common center of Gravity*; which Center (according to the known Laws of *Staticks*) is in a ſtreight Line connecting their reſpective Centers, ſo divided as that its parts be in reciprocal proportion to the Gravities of the two Bodies. As for Example Suppoſe the Magnitude (and therefore, probably, the Gravity) of the Moon to be about an *One and fourtieth part* of that of the Earth; (and thereabouts *Hevelius* in his *Selenography* page 203. doth out of *Tycho*, eſtimate the proportion; and an exact certainty is not neceſſary to our preſent buſineſſe.) And the diſtance of the Moons Center from the Center of the Earth, to be about *fifty ſix ſemidiameters* of the Earth, (as thereabouts he doth there eſtimate it, in its middle diſtance; and we need not be now very accurate in determining the numbers; wherein Aſtronomers are not yet very well agreed.) The diſtance of the Common Center of Gravity of the two Bodies, will be from that of the Earth, about a two and fourtieth part of fifty ſix Semidiameters; that is, about $\frac{56}{42}$ or $\frac{4}{3}$ of a Semidiameter; that is about $\frac{1}{3}$ of a Semidiameter of the Earth, above its ſurface, in the Air, directly between the Earth and Moon.

Now ſuppoſing the Earth and Moon, joyntly as one Body, carried about by the Sun in the great Orb of the *Annual* motion; this motion is to be eſtimated, (according to the Laws of *Staticks*, in other caſes,) by the motion of the common Center of Gravity of both Bodies. For we uſe in *Staticks*, to eſtimate a Body, or Aggregate of Bodies, to be moved upwards, downwards, or otherwiſe, ſo much as its Common Center of Gravity is ſo moved, howſoever the parts may change places amongſt themſelves.

And accordingly, the Line of the *Annual* motion, (whether *Circular* or *Elliptical*; of which I am not here to diſpute,) will be deſcribed, not by the Center of the Earth (as we commonly eſtimate it, making the Earth a Primary and the Moon a Secondary Planet,) nor by the Center of the Moon, (as they would do, who make the Moon the Primary and the Earth a

Secondary Planet, againſt which we were before diſputing:) But by the ***Common Center of Gravity of the Bodies, Earth and Moon***, as one Aggregate.

See Fig. 2. and 3.

Now ſuppoſing A B C D E to be a part of the great Orb of the *Annual* motion, deſcribed by the Common Center of Gravity, in ſo long time as from a *Full-Moon* at A to the next *New-Moon* at E; (which, though an Arch of a *Circle* or *Ellipse*, whoſe Center we ſuppoſe at a due diſtance below it; yet being but about $\frac{1}{25}$ of the whole, may well enough be here repreſented by a ſtreight Line:) the Center of the Earth at T, and that of the Moon at L, muſt each of them (ſuppoſing their common Center of Gravity to keep the Line A E) be ſuppoſed to deſcribe a *Periphery* about that Common Center, as the Moon deſcribes her Line of *Menſtrual* motion. (Of which I have (in the *Scheme*) onely drawn that of the *Earth*; as being ſufficient to our preſent purpoſe; parallel to which, if need be, we may ſuppoſe one deſcribed by the Moon; whoſe diſtance is alſo to be ſuppoſed much greater from T than in the *figure* is expreſſed, or was neceſſary to expreſſe.) And in like manner E F G H I, from that *New-moon* at E, to the next *Full-moon* at I.

From A to E (from Full-moon to New-moon,) T moves (in its own *Epicycle*) upwards from the Sun: And from E to I, (from New-moon to Full-moon) it moves downwards, toward the Sun. Again, from C to G, (from laſt quarter to the following firſt quarter,) it moves *forwards according* to the *Annual* motion; But from G forward to C, (from the firſt Quarter to the enſuing laſt Quarter,) it moves *contrary* to the *Annual* motion.

It is manifeſt therefore, according to this Hypotheſis, that from Laſt quarter to Firſt quarter (from C to G, while T is above the Line of the *Annual* motion) its *Menſtrual* motion in its Epicycle *adds* ſomewhat of Acceleration to the *Annual* motion; and moſt of all at E, the New-moon: And from the firſt to the laſt quarter (from G forward to C, while T is below the Line of the *Annual* motion,) it *abates* of the *Annual* motion; and moſt of all at I, or A the Full-moon.

So that in purſuance of *Galilæo's* Notion, the *Menſtrual* adding to or detracting from the *Annual* motion, ſhould either leave behinde, or caſt forward, the looſe waters incumbent on the Earth, (and thereby cauſe a Tide, or accumulation of Waters;) and moſt of all at the Full-moon and New-moon, where thoſe Accelerations or Retardations are greateſt.

Now this *Menſtrual* motion, if nothing elſe were ſuperadded to the *Annual*, would give us two Tides in a moneth, and no more; (the one upon the Acceleration, the other on the Retardation;) at New moon and Full-moon; and two Ebbs, at the two Quarters; and in the Intervals, Riſing and Falling water.

But the *Diurnal* motion ſuperadded, doth the ſame to this *Menſtrual*, which *Galilæo* ſuppoſeth is to do to that *Annual*; that is, doth *Add* to, or *Subſtract* from, the *Menſtrual* Acceleration or Retardation; and ſo gives us Tide upon Tide.

See Fig. 4. For in whatſoever part of its Epicycle, we ſuppoſe T to be; yet becauſe, while by its *Menſtrual* motion the Center moves in the Circle L T N; each point in its ſurface, by its diurnal motion moves in the Circle L M N: whatever effect (accelerative or tardative) the *Menſtrual* would give, that effect by the *Diurnal* is increaſed in the parts L M N (or rather l M n. the Semicircle) and moſt of all at M: but diminiſhed in the parts N O L (or rather n O l) and moſt of all at O. So that at M, and O, (that is when the Moon is in the *Meridian* below or above the *Horizon*,) we are to have the Diurnal Tide or High-water, occaſioned by the greateſt Acceleration or Retardation, which the *Diurnal* Arch gives to that of the *Menſtrual*: which ſeems to be the true cauſe of the *Daily Tides*. And withall gives an account, not onely why it ſhould be *every* day; but likewiſe, why at *ſuch a time* of the day; and why this time ſhould in a moneth run through the whole 24 hours; *viz.* becauſe the Moons coming to the *Meridian* above and below the *Horizon*, (or as the Seamen call it, the *Moons Southing*, and *Northing*,) doth ſo: As likewiſe of the *Spring-tides* and *Neap-tides*. For, when it ſo happens, that the *Menſtrual* and *Diurnal* Accelerations or Retardations, be coincident, (as at New moons and Full-moons they are.) the effect muſt needs be the greater. And although (which is not to be diſſembled) this happen but to one of the two Tides; that is, the Night-tide at the New-moon (when both motions do moſt of all Accelerate,) and the Day-tide at Full-moon (when both do moſt Retard the *Annual* motion;) Yet, this tide being thus raiſed by two concurrent cauſes; though the next Tide have not the ſame cauſe alſo, the *Impetus* contracted will have influence upon the next Tide; Upon a like reaſon, as a *Pendulum* let fall from a higher Arch, will (though there be no new cauſe to occaſion it) make the Vibration on the other ſide (beyond the Perpendicular) to be alſo greater: Or, of water in a broad Veſſel, if it be ſo jogged, as to be caſt forward to a good height above its Levell, will upon its recoyling, by its own gravity, (without any additional cauſe) mount ſo much the higher on the hinder part.

But here alſo we are to take notice, that though all parts of the Earth by its *Diurnal* motion do turn about its Axis, and deſcribe *parallel* Circles; yet not *equal* Circles; but *greater* neer the *Æquinoctial*, and *leſſer* near the *Poles*, which may be a cauſe why the Tides in ſome parts may be much greater than in others. But this belongs to the *particular* conſiderations, (of which we are not now giving an Account:) not to the *general* Hypotheſis.

Having thus endeavoured to give an account of the *Diurnal* and *Menſtrual* Periods of Tides; It remains that I endeavour the like as to the *Annual*. Of which there is, at leaſt, thus much agreed; That, at ſome times of the year, the Tides are noted to be much higher, than at other times.

But here I have a double task; *Firſt*, to rectify the Obſervation; and *then*, to give an account of it.

As to the *Firſt*; It having been obſerved (groſly) that thoſe high Tides have uſed to happen about the *Spring* and *Autumn*; it hath been generally taken for granted (without any more nice obſervation) that the *two Æquinoxes* are the proper times, to which theſe *Annual high Tides* are to be referred; And ſuch cauſes ſought for, as might beſt ſute with ſuch a Suppoſition.

But it is now, the beſt part of twenty years, ſince I have had frequent occaſions to converſe with ſome Inhabitants of *Rumney-marſh* in *Kent*; where the Sea being kept out with great Earthen walls, that it do not at high water overflow the Levell;

and I

and the Inhabitants livelyhood depending moſt on grazing, or feeding Sheep; they are (as you may believe they have reaſon to be) very vigilant and obſervant, at what times they are moſt in danger of having their Lands drowned. And I find them generally agreed, by their conſtant Obſervations, (and Experience dearly bought) that their times of danger are about the beginning of *February* and of *November*: that is, at thoſe Spring Tides which happen near thoſe times; to which they give the names of *Candlemaſs-ſtream* and *Allhallond-ſtream*: And if they ſcape thoſe Spring-tides, they apprehend themſelves out of Danger for the reſt of the year. And as for *March* and *September* (the two *Æquinoxes*) they are as little ſolicitous of them, as of any other part of the year.

This, I confeſs, I much wondred at, when I firſt heard it; and ſuſpected it to be but a miſtake of him, that firſt told me, though he were indeed a perſon not likely ſo to be miſtaken, in a thing wherein he was ſo much concerned: But I ſoon found, that it was not onely his, but a general obſervation of others too; both there, and elſewhere along the Sea coaſt. And though they did not pretend to know any reaſon of it, (nor ſo much as to enquire after it;) Yet none made doubt of it; but would rather laugh at any that ſhould talk of *March* and *September*, as being the dangerous times. And ſince that time, I have my ſelf very frequently obſerved (both at *London* and elſewhere, as I have had occaſion) that in thoſe months of *February* and *November*, (eſpecially *November*) the Tides have run much higher, than at other times: Though I confeſs, I have not been ſo diligent to ſet down thoſe Obſervations, as I ſhould have done. Yet this I do particularly very well remember, that in *November* 1660. (the ſame year that his Majeſty returned) having occaſion to go by Coach from the *Strand* to *Weſtminſter*, I found the Water ſo high in the middle of *King-ſtreet*, that it came up, not onely to the *B*oots, but into the *B*ody of the Coach; and the *Pallace-yard* (all ſave a little place near the *Weſt-End*) overflow'd; as likewiſe the Market-place; and many other places; and their Cellars generally filled up with Water. And in *November* laſt, 1665. it may yet be very well remembred, what very high Tides there were, not onely on the Coaſts of *England*, (where much hurt was done by it) but much more in *Holland*, where by reaſon of thoſe Inundations, many Villages and Towns were overflow'd. And though I cannot ſo particularly name other years, yet I can very ſafely ſay, that I very often obſerved Tides ſtrangely high about thoſe times of the year.

This Obſervation did for divers years cauſe me much to wonder, not only becauſe it is ſo contrary to the received opinion of the two *Æquinoxes*; but becauſe I could not think of any thing ſignal at thoſe times of the year: as being neither the two *Æquinoxes*, nor the two *Solſtices*, nor the Sun's *Apogæum* and *Perigæum*; (or Earths *Aphelium* and *Perihelium*;) nor indeed, at contrary times of the year, which at leaſt, would ſeem to be expected. From *Alhollandtide* to *Candlemaſs* being but three months; and from thence to *Alhollandtide* again nine months.

At length it came into my mind, about four years ſince, that though there do not about theſe times happen any *ſingle* ſignal Accident, which might caſt it on theſe times, yet there is a *compound of two* that may do it: Which is the *Inequality* of the *Natural day* (I mean that of 24. hours, from noon to noon) ariſing at leaſt from a double cauſe; either of which ſingly would caſt it upon other times, but both joyntly on thoſe.

It's commonly thought, how unequal ſoever the length be of the *Artificial* dayes as contradiſtinguiſhed to nights, yet that the *Natural* Day, reckoning from noon to noon, are all *equal*: But *Aſtronomers* know well, that even theſe dayes are *unequal*.

For, this *Natural* Day is meaſured *not onely* by one intire converſion of the *Æquinoctial*, or 24. *Æquinoctial* hours, (which is indeed taken to be performed in equal times,) *but* increaſes by ſo much, as anſwers to that part of the *Sun's* (or *Earths*,) Annual motion as is performed in that time. For, when that part of the *Æquinoctial*, which (with the *Sun*) was at the *Meridian* yeſterday at noon, is come thither again to day, it is not yet *Noon* (becauſe the Sun is not now at the place where yeſterday he was, but is gone forward about one degree, more or leſs) but we muſt ſtay till that place, where the *Sun* now is, comes to the *Meridian* before it be now *Noon*.

Now this Additament (above the 24 *Æquinoctial* hours, or intire converſion of the *Æquinoctial*) is upon a double account unequal. *Firſt*, becauſe the Sun, by reaſon of its *Apogæum* and *Perigæum*, doth not at all times of the year diſpatch in one day an equal Arch of the *Ecliptick*; but greater Arches neer the *Perigæum*, which is about the middle of *December*; and leſſer neer the *Apogæum*, which is about the middle of *June*: As will appear ſufficiently by the *Tables* of the Sun's Annual motion. *Secondly*, though the Sun ſhould in the *Ecliptick* move alwaies at the ſame rate; yet equal Arches of the *Ecliptick* do not in all parts of the *Zodiack* anſwer to equal Arches of the *Æquinoctial*, by which we are to eſtimate time: Becauſe ſome parts of it, as about the two *Solſticial* Points, lie nearer to a *parallel* poſition to the *Æquinoctial*, than others, as thoſe about the two *Æquinoctial* points, where the *Ecliptick* and *Æquinoctial* do interſect; whereupon an Arch of the *Ecliptick*, neer the *Solſticial* points anſwers to a greater Arch of the *Æquinoctial*, than an Arch equal thereunto neer the *Æquinoctial* points: As doth ſufficiently appear by the *Tables* of the Suns *right Aſcenſion*.

According to the *firſt* of theſe cauſes, we ſhould have the longeſt *natural* daies in *December*, and the ſhorteſt in *June*, which if it did operate alone, would give us at thoſe times two *Annual* High-waters.

According to the *ſecond* cauſe, if operating ſingly, we ſhould have the longeſt daies at the two Solſtices in *June* and *December*, and the two ſhorteſt at the *Æquinoxes* in *March* and *September*; which would at thoſe times give occaſion of four *Annual* High-waters.

But the true *Inequality* of the Natural Days, ariſing from a *Complication of thoſe two cauſes*, ſometimes croſſing and ſometimes promoting each other: though we ſhould find ſome increaſes or decreaſes of the *Natural* daies at all thoſe ſeaſons anſwerable to the reſpective cauſes (and perhaps of Tides proportionably thereunto:) yet the longeſt and ſhorteſt *natural daies* abſolutely of the whole year (ariſing from this complication of Cauſes) are about thoſe times of *Allhallontide* and *Candlemas*; (or not far from them) about which thoſe *Annual* High-tides are found to be: As will appear by the *Tables of Æquation* of *Natural* daies. And therefore I think, we may with very good reaſon caſt this *Annual* Period upon that cauſe, or rather complication of cauſes. For (as we before ſhewed in the *Menſtrual* and *Diurnal)* there will, by this inequality of Natural daies, ariſe a *Phyſical* Acceleration and Retardation of the Earths *Mean* motion, and accordingly a caſting of the Waters backward or forward; either of which, will cauſe an Accumulation or High-water.

'Tis true, that theſe longeſt and ſhorteſt daies, do (according to the *Tables*, ſome at leaſt) fall rather before, than after *Alhallontide* and *Candlemas* (to wit the ends of *October* and *January*;) but ſo do alſo (ſometimes) thoſe high Tydes: And it is not yet ſo well agreed amongſt *Aſtronomers*, what are all the Cauſes (and in what degrees) of the Inequality of Natural daies; but that there be diverſities among them, about the true time: And whether the introducing of this New Motion of the Earth in its *Epicycle* about this Common Center of *Gravity*, ought not therein alſo to be accounted for, I will not now determine: Having already ſaid enough, if not too much, for the explaining of this general Hypotheſis, leaving the particularities of it to be adjuſted according to the true meaſures of the motions; if the General Hypotheſis be found fit to be admitted.

Yet this I muſt add, (that I be not miſtaken) that whereas I caſt the time of the daily Tydes to be at all places, when the Moon is there in the *Meridian*; it muſt be underſtood of *open* Seas, where the water hath ſuch free ſcope for its motions, as if the whole Globe of Earth were equally covered with water: Well knowing, that in *Bayes* and *In-land-Channels*, the poſition of the Banks and other like cauſes muſt needs make the times to be much different from what we ſuppoſe in the open Seas: And likewiſe, that even in the Open Seas, *Iſlands*, and *Currents*, *Gulfs* and *Shallows*, may have ſome influence, though not comparable to that of *Bays* and *Channels*. And moreover, though I think, that Seamen do commonly reckon the time of High-water in the *Open* Seas, to be then, when the Moon is there in the *Meridian* (as this Hypotheſis would caſt it:) Yet I do not take my ſelf to be ſo well furniſhed with a *Hiſtory of Tides*, as to aſſure my ſelf of it; much leſs to accommodate it to particular places and caſes.

Having thus diſpatched the main of what I had to ſay concerning the Seas Ebbing and Flowing: Had I not been already too tedious, I ſhould now proceed to give a further reaſon, why I do introduce this conſideration of the *Common Center of Gravity* in reference to *Aſtronomical Accounts*. For indeed, that which may poſſibly ſeem at firſt to be an Objection *againſt* it, is with me one reaſon *for* it.

It may be thought perhaps, that if the Earth ſhould thus deſcribe an *Epicycle* about the Common Center of Gravity, it would (by this its change of place) diſturbe the *Cæleſtial* motions; and make the *apparent* places of the Planets, eſpecially ſome of them, different from what they would otherwiſe be. For though ſo ſmall a removal of the Earth, as the *Epicycle* would cauſe (eſpecially if its *Semidiameter* ſhould not be above $1\frac{1}{3}$ of the Earths Semidiameter) would ſcarce be ſenſible (if at all) to the remoter Planets; yet as to the nearer it might.

Now though what *Galilæo* anſwers to a like Objection in his *Hypotheſis*; (that its poſſible there may be ſome ſmall difference, which *Aſtronomers* have not yet been ſo accurate, as to obſerve) might here perhaps ſerve the turn; Yet my anſwer is much otherwiſe; to wit, that ſuch difference hath been obſerved, and hath very much puzzeled *Aſtronomers* to give an account of. About which you will find Mr, *Horrocks* (in ſome of his Letters, whereof I did formerly, upon the Command of the *Royal Society*, make an *Extract*) was very much perplexed; and was fain, for want of other relief, to have recourſe to ſomewhat like *Keplers* amicable *Fibres*, which did according to the ſeveral poſitions of the Moon, accelerate or retard the Moon's motion; which *amicable Fibres* he had no affection to at all (as there appears) if he could any other waies give account of thoſe little inequalities; and would much rather (I doubt not) have embraced this Notion of the Common Center of Gravity, to ſalve the *Phænomenon*, had it come to his mind, or been ſuggeſted to him. And you find, that other *Aſtronomers* have been ſeen to bring in (ſome upon one ſuppoſition, ſome upon another) ſome kind of *Menſtrual Æquation*, to ſolve the inequalities of the Moon's motion, according to her *Synodical* Revolution, or different Aſpects (of New-moon, Full Moon, &c.) beſide what concerns her own *Periodical* motion.

For which, this conſideration of the *Common Center of Gravity of the Earth and Moon*, is ſo proper a remedy (eſpecially if it ſhall be found preciſely to anſwer thoſe *Phænomena*, which I have not Examined, but am very apt to believe) that it is ſo far from being, with me, an Objection againſt it, that it is one of the reaſons, which make me inclinable to introduce it.

I muſt before I leave this, add one Conſideration more, That if we ſhall upon theſe Conſiderations think it reaſonable, thus to conſider the *Common Center of Gravity of the Earth and Moon*; it may as well be thought reaſonable, that the like Conſideration ſhould be had of *Jupiter* and his four *Satellites*, which according to the Complication of their ſeveral motions, will ſomewhat change the poſition of *Jupiter*, as to that *Common center of Gravity* of all theſe Bodies; which yet, becauſe of their ſmallneſs, may chance to be ſo little, as that, at this diſtance, the change of this apparent place may not be diſcernable. And what is ſaid of *Jupiter*, is in the like manner to be underſtood of *Saturne* and his *Satelles*, diſcovered by *Hugenius*: For all theſe *Satellites* are to their *Principals*, as ſo many Moons to the Earth. And I do very well remember, in the Letters forecited, Mr. *Horrocks* expreſſeth ſome ſuch little inequalities in *Saturnes* motion, of which he could not imagine what account to give, as if (to uſe his Expreſſion) this crabbed *Old Saturn* had deſpiſed his *Youth*. Which, for ought I know, might well enough have been accounted for, if at that time the *Satelles* of *Saturn* had been diſcovered, and that Mr. *Horrocks* had thought of ſuch a motion as the *Common Center of Gravity* of *Saturn* and his *Companion*, to be conſiderable, as to the guiding of his motion.

You have now, in obedience to your Commands, an Account of my thoughts, as to this matter, though yet immature and unpoliſhed: What uſe you will pleaſe to make of them, I ſhall leave to your prudence, &c.

An APPENDIX, *written by way of Letter to the* Publiſher; *Being an Anſwer to ſome Objections, made by ſeveral Perſons, to the precedent Diſcourſe.*

I Received yours; and am very well contented, that *objections* be made againſt my *Hypotheſis* concerning *Tydes*: being

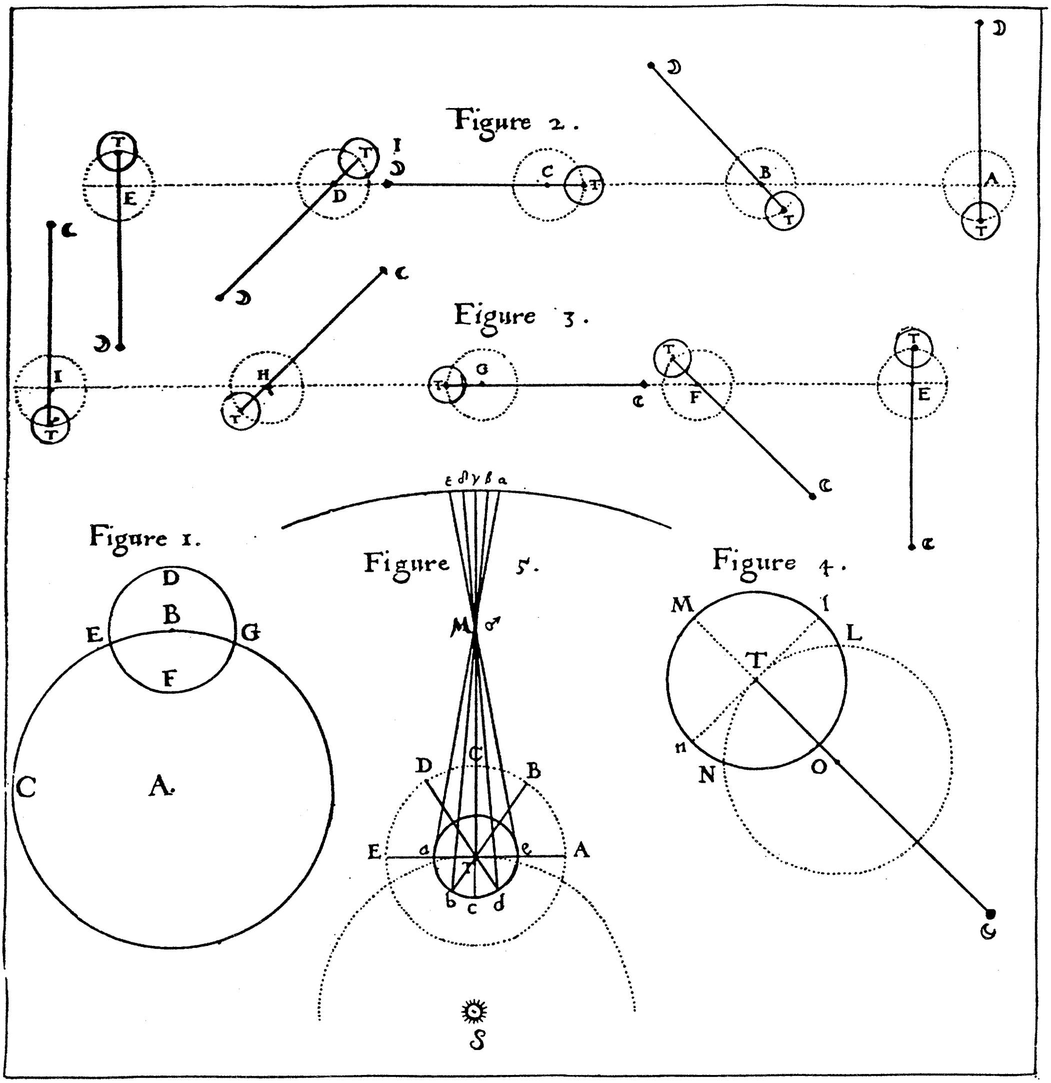
Figure 2.
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